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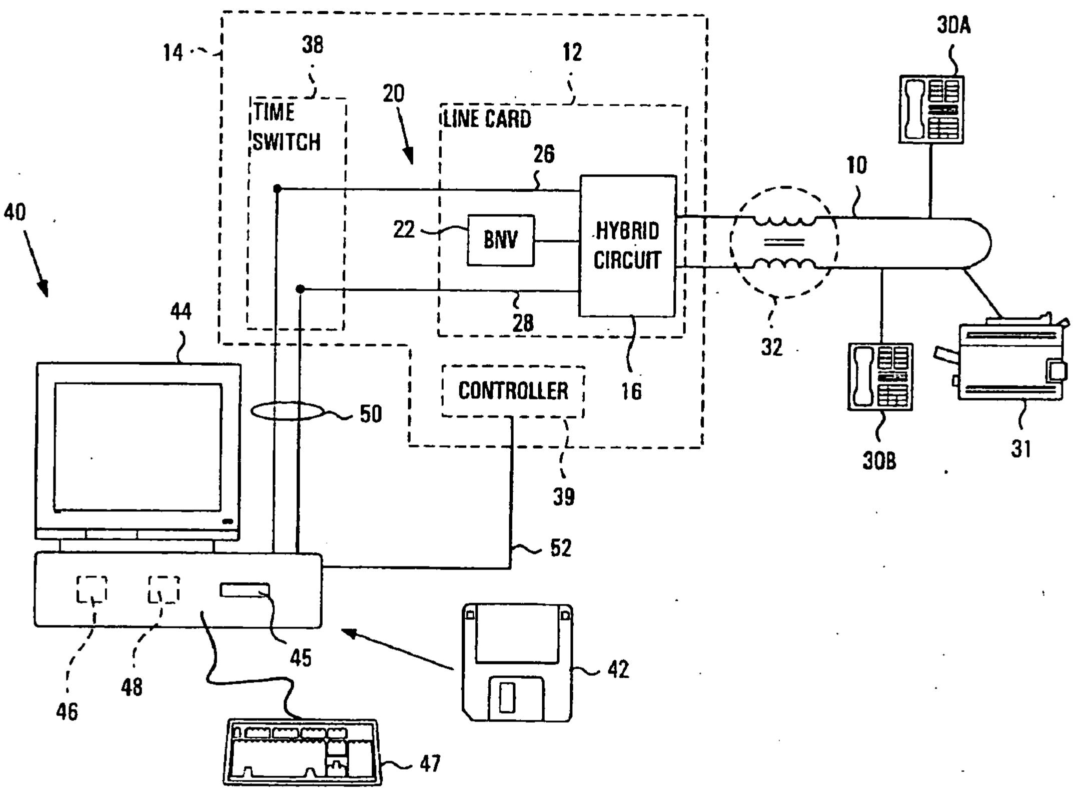
(54) METHODE POUR DETECTER LA PRESENCE DE BOBINES DE CHARGEMENT SUR LES BOUCLES D'ABONNES, EN UTILISANT LES MESURES DE PERTES TRANS-HYBRIDES

(54) A METHOD OF DETECTING THE PRESENCE OF LOAD COILS ON SUBSCRIBERS LOOPS, BY THE USE OF TRANS-HYBRID LOSS MEASUREMENTS



(57) A method for determining whether a subscriber loop has load coils comprises applying test tones in the voice band to a hybrid circuit terminating the subscriber loop at the transmitter pair of the four-wire side of the circuit. Reflections are measured at the receiver pair of the four-wire side of the hybrid circuit. If the amplitude of the reflections as a function of frequency decrease monotonically, the subscriber loop is declared to be free of load coils.

ABSTRACT

A method for determining whether a subscriber loop has load coils comprises applying test tones in the voice band to a hybrid circuit terminating the subscriber loop at the transmitter pair of the four-wire side of the circuit. Reflections are measured at the receiver pair of the four-wire side of the hybrid circuit. If the amplitude of the reflections as a function of frequency decrease monotonically, the subscriber loop is declared to be free of load coils.

A METHOD OF DETECTING THE PRESENCE OF LOAD COILS ON SUBSCRIBER LOOPS, BY THE USE OF TRANS-HYBRID LOSS MEASUREMENTS

BACKGROUND OF THE INVENTION

This invention relates to a method and apparatus for detecting the presence of load coils on a subscriber loop.

Where it is desired to use an analog subscriber loop for data transmission, one approach is to send the data on the line in a frequency band which is much higher than the frequency band for voice. This is the approach used with the Asynchronous-Digital Subscriber Line (ADSL) standard. Multiplexing data on the line is useful in, for example, allowing high speed internet access over an analog telephone line.

Subscriber loops suffer from the fact that signal attenuation is a function of frequency. Further, the longer the subscriber loop, the more pronounced is this effect. This frequency dependent attenuation results in linear distortion of a signal. This signal distortion can be lessened by inserting an inductance at intervals along a subscriber loop; this inductance takes the form of load coils.

While load coils enhance frequency characteristics in the voice band, each coil acts as a low pass filter (LPF). Thus, a subscriber loop with a load coil is unsuitable for carrying a high frequency data signal. Therefore, prior to undertaking the expense of configuring a subscriber loop to carry a high frequency data signal, it is desirable to test the subscriber loop for the presence of load coils.

A subscriber loop is a two-wire line with a tip line and a ring line. The loop terminates at a line card in the central office. One known method of testing from the presence of load coils on the loop is to disconnect the loop from its terminating line card then connect test equipment to the tip and ring wires to measure the tip/ring impedance as seen

from the line card end of the loop. If this impedance has a high reactive component, this is indicative of load coils.

SUMMARY OF THE INVENTION

A method of detecting the presence of load coils according to this invention involves tests at the four-wire side of a hybrid circuit connected to the subscriber loop. More particularly, to determine whether a subscriber loop has load coils, test tones in the voice band are applied to a hybrid circuit connected to the subscriber loop at the transmitter path of the four-wire side of the circuit. Reflections are measured at the receiver path of the four-wire side of the hybrid circuit. If the amplitude of the reflections as a function of frequency decrease monotonically, the subscriber loop is declared to be free of load coils. Apparatus is also provided to effect this method. Tests at the four-wire side of a hybrid circuit are convenient for the telephone operating company and allow test equipment to reside at, and be integrated with, the central office.

Accordingly, in accordance with one aspect of the present invention, there is provided a method for testing for load coils on a subscriber loop, comprising the steps of: applying tones at different frequencies in a voice band to a four-wire side of a hybrid circuit connected to subscriber loop; measuring reflections at said four-wire side of said hybrid circuit resulting from said step of applying tones; based on said step of measuring reflections, determining whether said subscriber loop has at least one load coil.

According to another aspect of the present invention, there is provided apparatus for testing for load coils on a subscriber loop comprising: a test signal generator for applying tones at different frequencies a band from about 300 Hz to about 3500 Hz to a four-wire side of a hybrid circuit connected to said subscriber loop; a determiner for measuring reflections at said four-wire side of said hybrid circuit resulting from said step of applying tones and for, based on measured reflections, determining whether said subscriber loop has at least one load coil.

According to a further aspect of the present invention, there is provided a computer media product comprising: means for applying tones at different frequencies in a voice band to a four-wire side of a hybrid circuit connected to said subscriber loop; means for measuring reflections at said four-wire side of said hybrid circuit resulting from said step of applying tones; and means for, responsive to said means for measuring, determining whether said subscriber loop has at least one load coil.

BRIEF DESCRIPTION OF THE DRAWINGS

In the figures which illustrate example embodiments of the invention,

figure 1 is a schematic diagram of a system including apparatus made in accordance with this invention,

figures 2a and 2b comprise a flow diagram for the processor of figure 1, and

figure 3 is a schematic diagram of a system including apparatus made in accordance with another embodiment of this invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

While analog subscriber loops are two-wire lines, signal transmission from one line to another line involves separate paths for transmission and reception. Prior to the advent of digital technologies, the transmission path was implemented with a pair of wires and the reception path with another pair of wires. For this reason, the separate transmission and reception paths were known as a four-wire connection. With digital technologies four wires are not always used to implement the transmission and reception paths. Nevertheless, the separate paths are still known as a four-wire connection. Typically a telephone switch terminates four-wire connections from remote switches and two-wire lines for its subscriber

loops. Each four-wire to two-wire interface in the switch is known as a hybrid circuit. A drawback with a hybrid circuit is that if the impedance of the two-wire side does not match that of the four-wire side, a part of the signal on the transmitter path of the four-wire side will be reflected back to the receiver path of the four-wire side while only the remainder of the signal is passed to the two-wire side. This results in an echo. To reduce this effect, an impedance is added to the hybrid circuit in an effort to balance the impedance of the four-wire connection with the two-wire line. This balancing impedance is known as a balanced network value (BNV). In practice, one of three different BNVs are typically added to a hybrid circuit: a non-loaded BNV, a loaded BNV, and a $900\Omega + 2.16\mu F$ BNV. Since the impedance on the four-wire and two-wire sides are not constant (i.e., they are functions of frequency), the BNV is only a rough approximation of a matching impedance. Consequently, there are inevitably some reflections from a transmission path to a receiver path of a hybrid circuit. These reflections are manifested by variations of the trans-hybrid loss (THL) of the hybrid circuit.

Since THL results from imbalanced impedances, it is a function of frequency. It has been observed that the THL of a hybrid circuit increases monotonically with frequency in the voice band where the two-wire loop is unloaded. It has further been observed that the THL of a hybrid circuit as a function of frequency exhibits local maxima and minima in the voice band where the two-wire loop of the hybrid circuit is loaded. The number of these maxima and minima generally increase with the number of load coils on the loop. By "voice band" is meant the frequency range of 300Hz to 3,500Hz, +/- about 100 Hz at either end of the range. These observations are utilised in a method and apparatus to sample the THL of a hybrid circuit in the voice band to test for load coils.

The method involves applying tones to the transmitter pair at the four-wire side of a hybrid circuit at each of several different frequencies in the voice band and determining whether the reflected signals at the receiver path indicate a monotonic increase in the THL with frequency or a THL with maxima and minima. It has been discovered that the confidence level for such a determination is higher if at least about ten different frequency tones are applied with a maximum frequency step between test tones being not greater than 500 Hz.

An off-hook telephone station apparatus on a loop adds additional factors to the impedance of the loop. Therefore, it is preferred that the THL be tested while all telephone station apparati on a loop are on-hook. Further, it has been observed that the confidence level for a determination of whether or not the subscriber loop has load coils is higher if the hybrid circuit has a non-loaded BNV. Therefore, it is preferred that testing occur while the BNV is non-loaded.

Figure 1 illustrates a set-up for testing a subscriber line for load coils. Turning to figure 1, as is typical, a two-wire subscriber loop 10 is terminated at a line card 12 of a telephone switch 14. The line card also receives a four-wire connection 20; loop 10 and four-wire connection 20 are interfaced by a hybrid circuit 16. The hybrid circuit is assumed to be an electronic hybrid circuit. The BNV of the hybrid circuit is indicated at 22. The four-wire connection comprises a transmission path 26 and a receiver path 28. The two-wire subscriber loop 10 has loop apparatus, such as telephone station apparatus 30a, 30b and facsimile machine 31 associated therewith as well as a load coil 32. The four-wire side of the hybrid circuit extends into time switch 38 of switch 14; the time switch and line card operate under control of switch controller 39.

A tester for determining whether loop 10 has one or more load coils comprises computer 40 operating under control of software loaded into memory 48 and under control of user inputs through user interface 47. The computer also comprises a reader 45 for reading software from computer disk 42 into memory 48, a display 44, and a processor 46. Computer 40 is connected to a test trunk 50 to time switch 38 and on path 52 to switch controller 39.

The sequence of operation of the processor 46 is set out in figures 2a and 2b. Turning to figures 2a and 2b, after computer 40 is connected to test trunk 50, on receiving a user request to test a particular loop, it signals controller 39 requesting a connection through the time switch to the hybrid circuit 16 of the loop 10 to be tested (S108). Next processor 46 obtains an indication of whether all apparati on loop 10 are on-hook (S110). A high impedance on the loop indicates all apparati are on-hook and the processor may

determine the impedance directly by testing the loop. Alternatively, the controller 39 may be able to supply processor 46 with an indication of whether all apparati on the loop are on hook. If not all apparati are on-hook, the test is aborted (S112). If all loop apparati are on-hook, the processor 46 prompts the controller 39 to set the BNV value to a non-loaded value (S114). Next a test tone of a pre-determined amplitude is sent on the transmitter pair of test trunk 50 to the hybrid circuit 16 (four wire interface) and the amplitude of the reflection measured on the receiver pair of test trunk 50 from the hybrid circuit (S116). The frequency for the test tone is then incremented (S120) and a test tone at the incremented frequency of a pre-determined amplitude is sent on the appropriate pair of trunk 50 (S116). This procedure of incrementing the frequency for the test tone, sending the test tone, and receiving the reflection, is repeated until a pre-determined number of reflection samples have been received (S122). The frequency dependence of the samples is then assessed to determine whether the amplitude of the reflections decreases (and hence the THL increases) monotonically with frequency (S124). If no, the subscriber loop is declared to have at least one load coil (S126) -- this may be communicated by the processor sending an indication to display 44. If yes, the subscriber loop is considered to be free of load coils (S128) -- and again, this may be communicated by the processor sending an indication to display 44.

As an alternative to step 124, the frequency dependence of the samples may be assessed to determine whether the reflections show local maxima and minima. If no, the subscriber loop is declared to be free of load coils and if yes, the subscriber loop is declared to have at least one load coil. As a further alternative, both a monotonic determination and a local extreme determination may be made. If both suggest either no load coils or the presence of load coils, this result is declared by the processor. If the results are conflicting, the processor declares the test inconclusive. This would prompt a user to repeat the test.

As aforenoted, the test tones should all fall within the voice band and it is preferred that at least ten test tones are sent, each at a frequency spaced from the frequency of other test tones by no more than about 500 Hz. There is, however, no necessity that the test tones be equally spaced in the frequency spectrum. Further, while not preferred, each test tone could have a different amplitude and, if so, the reflections need to be scaled

appropriately before a determination can be made as to the frequency dependence of the reflections.

In the described operation, a number of test signals are applied to the hybrid interface, each test signal comprising a single tone at a different frequency. Alternatively, the test signal may comprise a spectrum with at least ten spectral lines such that only one test signal is sent to complete the test. A pseudo-random noise signal could serve the function of such a test signal.

The apparatus would function if the processor did not check the impedance of the loop. In such instance, however, there is an increased risk the impedance of the loop could change during the test due the varying impedance of an off-hook apparatus or an apparatus going on-hook. This would perturb the THL of the interface which could give a false indication of a local maximum or minimum and, therefore, possibly a false indication as to whether the loop was loaded with one or more load coils. The apparatus would also instead of no-load use non-loaded function if the processor did not set the BNV value to a non-loaded value. However, in such case, it has been observed that the apparatus is more likely to make a false determination as to whether the loop is loaded with one or more load coils.

In place of reader 45 of figure 1 which is adapted to read computer disk 42, a reader adapted to read from a tape, memory chip, or other removable computer readable medium may be provided. Furthermore, the reader may be replaced by an interface which interfaces with an internet, intranet, dedicated data link, or the like for loading software from a remote computer readable medium into memory 48.

While the subject apparatus has been illustrated as comprising a processor with certain functionality, equally the processor may be replaced with separate components to effect this functionality.

The aforedesribed method may also be undertaken if the processor 40 of figure 1 is replaced by test equipment integrated with switch 14. Turning to figure 3 wherein like parts to those of figure 1 are given like reference numerals, switch 214 includes a test platform 260 with a test signal generator 262 connected to a transmit path of a trunk 250 and a test signal receiver connected to a receive path of trunk 250. The test platform communicates with controller 39 which may receive an operator input from operations, administration, and maintenance (OA&M) station 262. In operation, an operator at station 262 may request a test of a loop 10. Controller 39 may then establish a connection through time switch 38 from the test platform to the line card 12 of loop 10. The controller may then ensure apparatus connected to loop 10 are on-hook then generate a signal to set the BNV of the line card and signal the test platform to transmit a test signal spectrum. The reflection spectrum received by the test signal receiver 264 is passed to the controller. The controller then determines whether the subscriber loop has load coils and outputs this determination to station 262.

The described method relies on connecting test equipment to the four-wire interface of the line card under test and measuring transhybrid loss (or gain). In contrast to known methods which require test equipment to be connected to the tip and ring lines, test equipment operating in accordance with this invention may be integrated with the central office equipment, or connected to the time switch of the central office.

Other modifications within the spirit of the invention will be apparent to those skilled in the art.

THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS

1. A method for testing for load coils on a subscriber loop, comprising the steps of:

applying tones at different frequencies in a voice band to a four-wire side of a hybrid circuit connected to subscriber loop;

measuring reflections at said four-wire side of said hybrid circuit resulting from said step of applying tones;

based on said step of measuring reflections, determining whether said subscriber loop has at least one load coil.

2. The method of claim 1 wherein said determining step comprises determining whether an amplitude of said reflections decreases monotonically as a function of frequency.

3. The method of claim 1 wherein said determining step comprises determining whether an amplitude of said reflections exhibits one or more local maximums or local minimums.

4. The method of claim 1 wherein said applying step comprises applying about ten different frequency tones each spaced in frequency from an adjacent tone by at most 500 Hz.

5. The method of claim 1 including the step of setting a balanced network value to a non-loaded value prior to said tone applying step.

6. The method of claim 5 including the step of monitoring whether any apparatus on said subscriber loop are on-hook and conducting said tone applying step only while said apparatus are on-hook.

7. A method for testing for load coils on a subscriber loop, comprising the steps of:

applying tones at different frequencies a band from about 300 Hz to about 3500 Hz to a four-wire side of a hybrid circuit connected to said subscriber loop;

measuring reflections at said four-wire side of said hybrid circuit resulting from said step of applying tones;

based on said step of measuring reflections, determining whether said subscriber loop has at least one load coil.

8. Apparatus for testing for load coils on a subscriber loop comprising:

a test signal generator for applying tones at different frequencies a band from about 300 Hz to about 3500 Hz to a four-wire side of a hybrid circuit connected to said subscriber loop;

a determiner for measuring reflections at said four-wire side of said hybrid circuit resulting from said step of applying tones and for, based on measured reflections, determining whether said subscriber loop has at least one load coil.

9. The apparatus of claim 8 including a balanced network value set signal generator for setting a balanced network value to a non-loaded value, and wherein said test signal generator is responsive prior to said tone applying step.

10. The method of claim 9 including a supervision signal receiver for receiving an indication whether each apparatus on said subscriber loop is on-hook and a test condition assurer responsive to an output of said supervision signal receiver for enabling said test signal generator while each said apparatus is on-hook.

11. A computer readable medium storing computer executable instructions, comprising:

means for applying tones at different frequencies in a voice band to a four-wire side of a hybrid circuit connected to said subscriber loop;

means for measuring reflections at said four-wire side of said hybrid circuit resulting from said step of applying tones; and

means for, responsive to said means for measuring, determining whether said subscriber loop has at least one load coil.

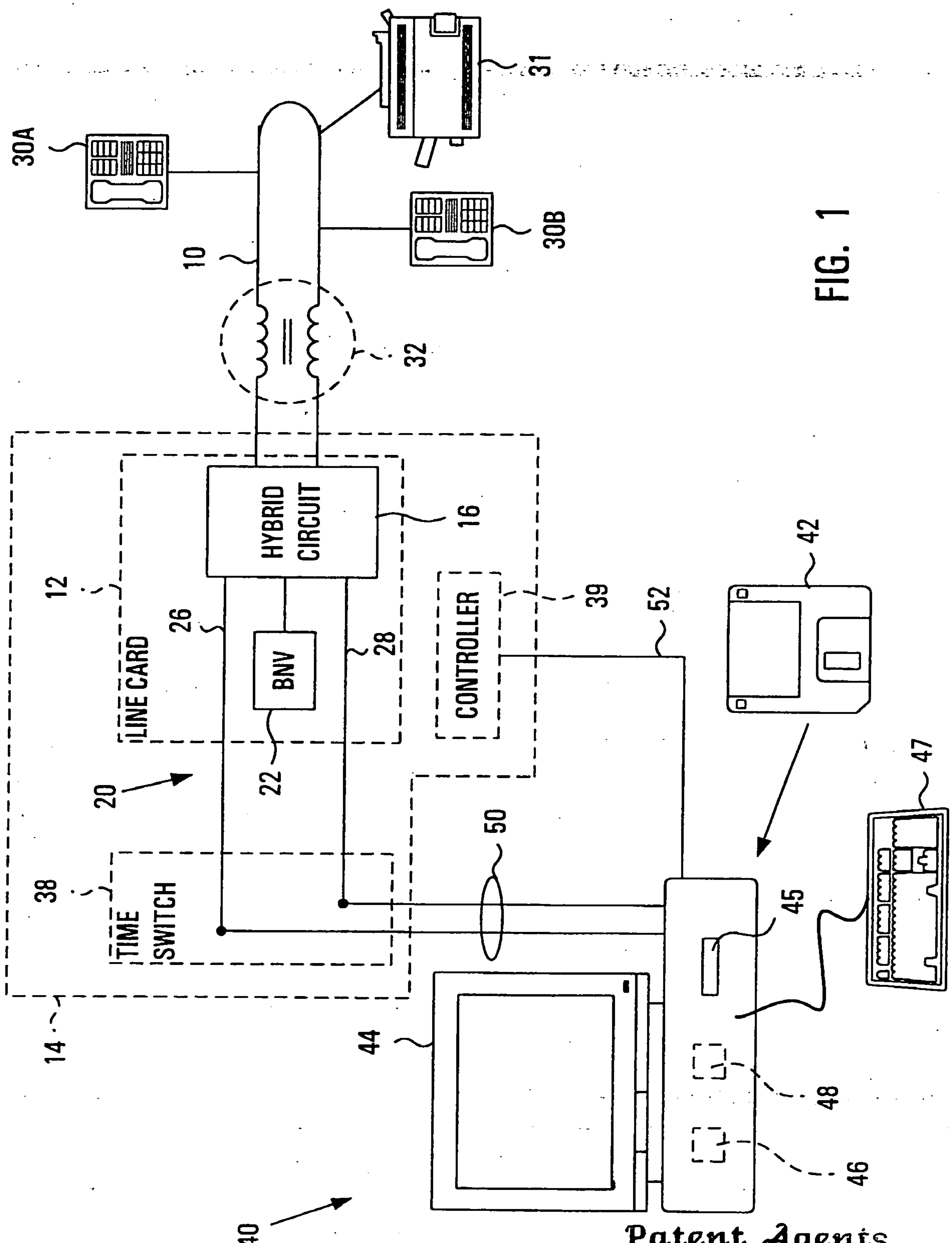

30A
31
10
30B
32
HYBRID CIRCUIT
16
12
26
LINE CARD
BNV
28
CONTROLLER
39
52
42
22
20
47
50
38
TIME SWITCH
45
14
44
48
46
40

FIG. 1

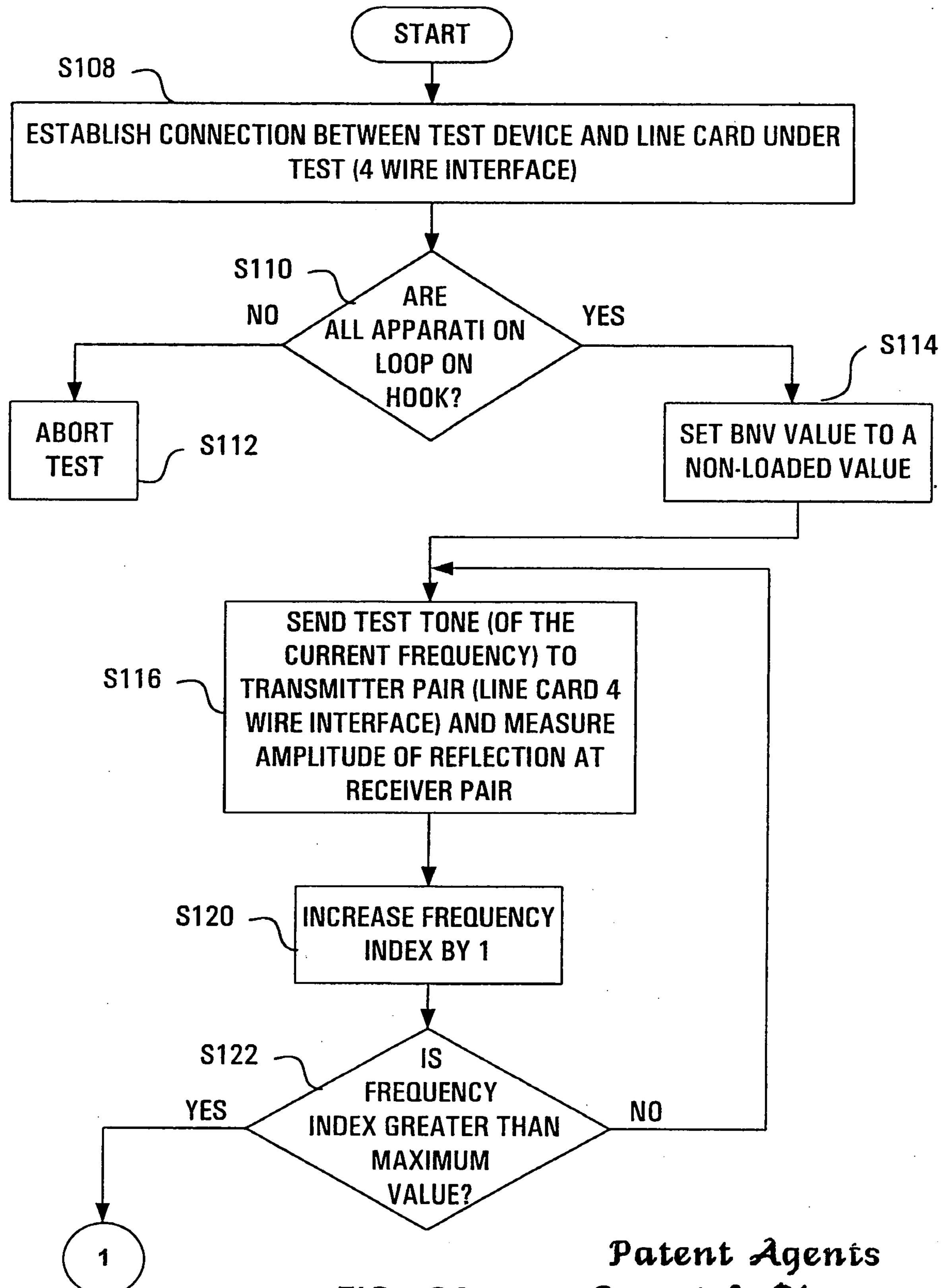


FIG. 2A

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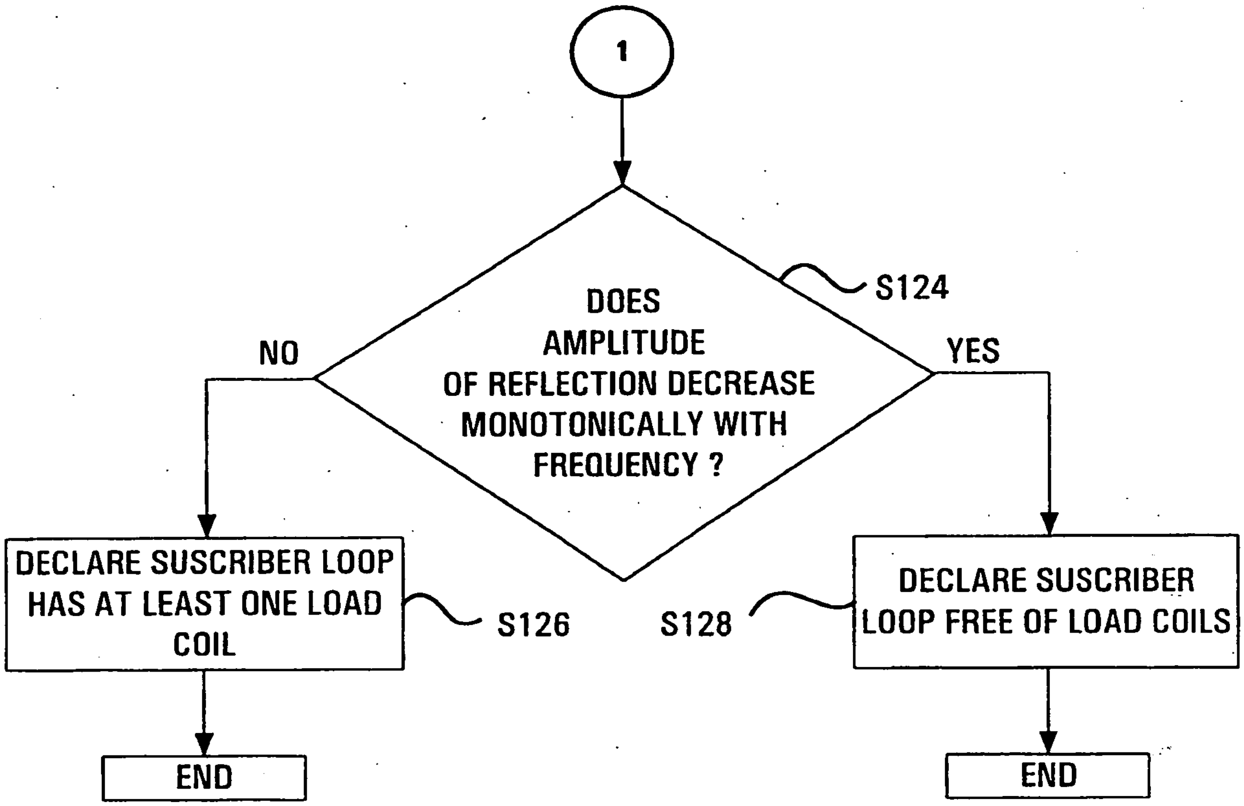

FIG. 2B

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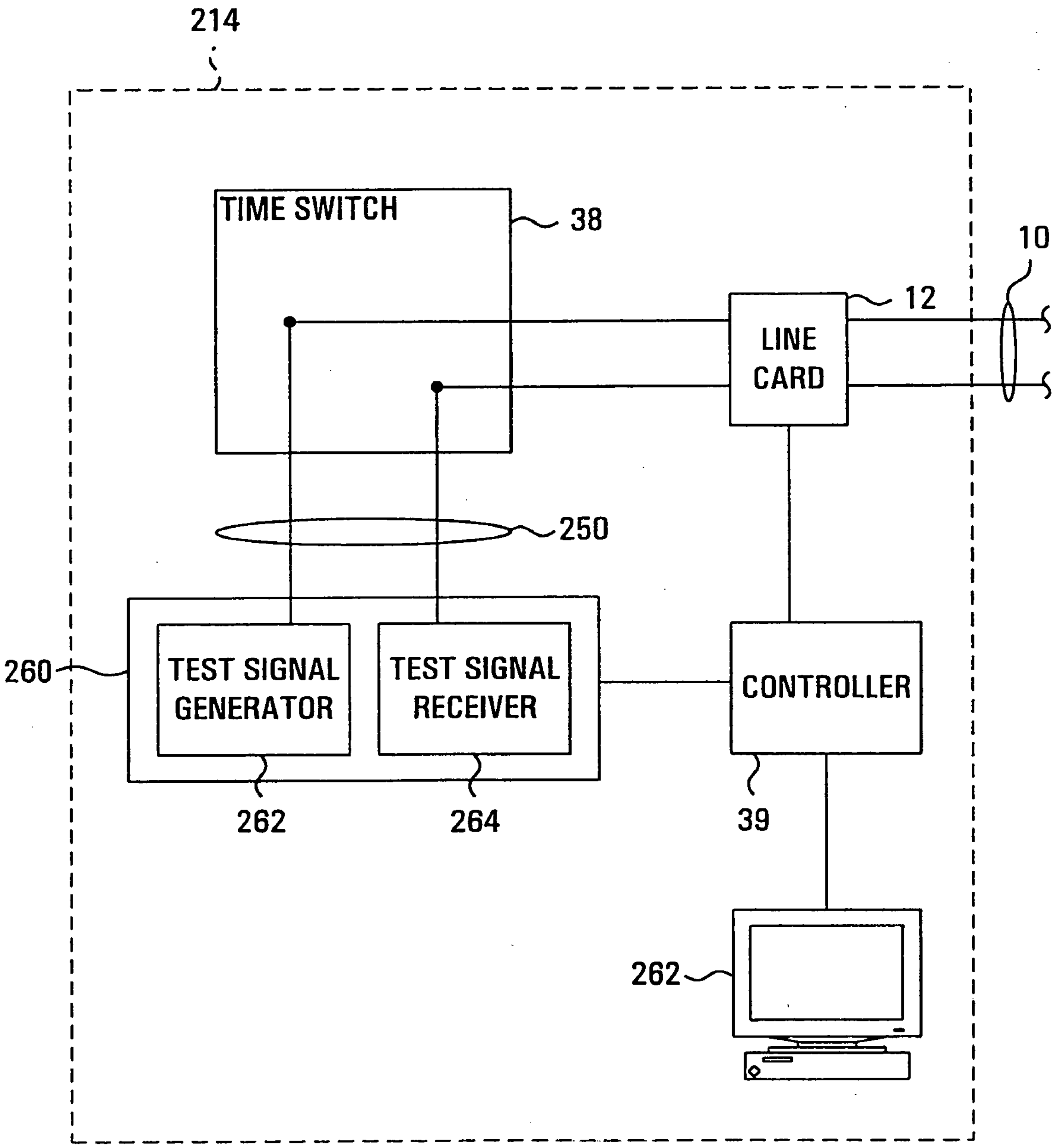

FIG. 3

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